

### **REMARKS**

This response is intended to be a complete response to the office action dated October 29, 2003. In view of the following discussion, the Applicants believe that all claims are in allowable form.

### **IN THE CLAIMS**

Claim 75 has been amended to add the word "and" after the penultimate limitation of the claim. The Applicants submit that this amendment was made for reasons unrelated to patentability and that no new matter has been added.

### **CLAIM REJECTIONS**

#### **I. 35 U.S.C. §112 Claims 69-80**

##### **A. Claims 55, 63, and 72**

Claims 55, 63, and 72 stand rejected under 35 U.S.C. §112. In response, the Applicants have amended these claims to more clearly recite aspects of the invention. Claim 55 has been amended to add a period to the end of the claim. Claim 63 has been amended to correct dependency from claim 54 to claim 62. Claim 72 has been amended to replace "the metal nitride layer" with "the second layer." The Applicants submit that no new matter has been entered.

Therefore, it is respectfully requested that this rejection be withdrawn.

##### **B. Claims 69 - 74**

Claims 69-74 stand rejected under 35 U.S.C. §112. The Examiner asserts that there is no support for claiming a first layer being tungsten. In response, the Applicants have amended claims 69 and 70 to remove tungsten as a first layer.

Therefore, it is respectfully requested that this rejection be withdrawn.

C. Claims 75-80

Claims 75-80 stand rejected under 35 U.S.C. §112. The Examiner asserts that there is no support for the interconnect gate widths as claimed in the preamble to claim 75. In response, the Applicants have amended claim 75 to recite "gate lengths" rather than "gate widths". The Applicants submit that gate lengths and gate widths refers to the same critical dimension and that, therefore, the amendment is not narrowing.

In the Detailed Description section of the application, the specification specifically points out that the inventive method for forming an interconnect structure "may be employed in an integrated circuit with gate lengths of .25  $\mu\text{m}$  and less...." (Application, p. 10, ll. 16-22.) The Detailed Description further states that "the present invention has been described with respect to its utility in integrated circuits that are constructed using .25  $\mu\text{m}$  and sub .25  $\mu\text{m}$  technology...." (Application, p. 43, ll. 4-6.)

Therefore, it is respectfully requested that this rejection be withdrawn.

D. SUPPLEMENTARY DECLARATION

The Examiner asserts that a supplementary declaration is required for matter not originally claimed or embraced in the statement of the invention. The Applicants acknowledge the requirement and will executed and submit a supplementary declaration under 37 C.F.R. §1.67 upon allowance of the application.

Therefore, it is respectfully requested that this rejection be withdrawn.

II. **35 U. S. C. §103 Claims 54-80**

A. Claims 54-69

Claims 54-69 stand rejected as being unpatentable over United States Patent Serial No. 5,714,418, issued February 3, 1998 to Bai et al. (hereinafter *Bai*), in view of United States Patent Serial No. 5,175,126, issued December 29, 1992 to Ho et al. (hereinafter *Ho*), United States Patent Serial No. 5,712,193, issued January 27, 1998 to Hower et al. (hereinafter *Hower*), or United States Patent Serial No. 5,685,960, issued November 11, 1997 to Fu et al. (hereinafter *Fu*), and United States Patent Serial No.

5,612,558, issued March 18, 1997 to Harshfield (hereinafter *Harshfield*). The Applicants respectfully disagree.

1. *Bai* in view of *Ho* and *Harshfield*

Independent claim 54 recites limitations not taught or suggested by any permissible combination the cited references. *Bai* describes a method for forming a bi-layer diffusion barrier for electrical interconnects whereby a capturing layer and a blocking layer are formed on the surface of the underlying substrate by a sputtering or a chemical vapor deposition (CVD) process. (*Bai*, col. 8, ll. 39-44). *Bai* does not teach or suggest depositing a layer of a refractory metal upon a substrate, forming a layer of metal nitride on said refractory metal, wherein said metal nitride layer is formed using a gas comprising a metallo-organic substance, and then exposing the metal nitride layer to a plasma to reduce the resistivity of said layer by removing carbon from the metal nitride layer, as recited in claim 54.

*Ho* teaches a process of making a TiN barrier layer by a reactive sputtering technique. (*Ho*, col. 6, ll. 35-37.) *Ho* further teaches treating the TiN layer with a hydrogen plasma to have hydrogen adsorb to the TiN grains at the grain boundaries and fill the grain boundaries such that subsequently deposited metal will not migrate through the TiN barrier layer. (*Ho*, col. 7, ll. 28-35.) *Ho* does not teach or suggest forming a layer of metal nitride using a gas comprising a metallo-organic substance, as recited in claim 54.

The Examiner cites *Harshfield* to teach depositing a layer of metal nitride using a gas comprising a metallo-organic substance and exposing the metal nitride layer to a plasma to reduce the resistivity of said layer by removing carbon from the metal nitride layer. However, this teaching is described in Application 08/498,990, filed July 6, 1995, from which the instant Application is a Continuation-In-Part. As the filing date of *Harshfield* is November 15, 1995, *Harshfield* is not prior art with respect to this teaching. Accordingly, the Applicants respectfully request that this reference be removed.

As such, *Ho* cannot be used to modify *Bai* in a manner that teaches or suggests a method for forming a structure for an integrated circuit including the steps of forming a

layer of metal nitride on a refractory metal using a gas comprising a metallo-organic substance, and then exposing the metal nitride layer to a plasma to reduce the resistivity of said layer by removing carbon from the metal nitride layer, as recited in claim 54. Therefore, a *prima facie* case of obviousness has not been established because the combination of the cited references fails to teach or suggest all of the claimed limitations. With respect to the Examiner's alternative stance of taking Official Notice, the Applicants submit that as the claimed invention is patentable over the art cited by the Examiner, Official Notice is not appropriate and should be withdrawn.

Thus, independent claim 54, and all claims depending therefrom, are patentable over *Bai* in view of *Ho*, *Hower*, or *Fu*, and *Harshfield*. Accordingly, the Applicants respectfully request that the rejection be withdrawn and the claims allowed.

2. *Bai* in view of *Hower* and *Harshfield*

*Harshfield* has been removed as prior art. *Bai* is discussed above. *Hower* teaches a method of plasma treating metal nitride films formed by sputtering or CVD in a nitrogen plasma in order to reduce silicon migration through the TiN layer. (*Hower*, col. 2, l. 47 to col. 3, l. 13.) *Hower* does not teach or suggest forming a layer of metal nitride using a gas comprising a metallo-organic substance, as recited in claim 54.

As such, *Hower* cannot be used to modify *Bai* in a manner that teaches or suggests a method for forming a structure for an integrated circuit including the steps of forming a layer of metal nitride on a refractory metal using a gas comprising a metallo-organic substance, and then exposing the metal nitride layer to a plasma to reduce the resistivity of said layer by removing carbon from the metal nitride layer, as recited in claim 54. Therefore, a *prima facie* case of obviousness has not been established because the combination of the cited references fails to teach or suggest all of the claimed limitations. With respect to the Examiner's alternative stance of taking Official Notice, the Applicants submit that as the claimed invention is patentable over the art cited by the Examiner, Official Notice is not appropriate and should be withdrawn.

Thus, independent claim 54, and all claims depending therefrom, are patentable over *Bai* in view of *Hower* and *Harshfield*. Accordingly, the Applicants respectfully request that the rejection be withdrawn and the claims allowed.

3. *Bai* in view of *Fu* and *Harshfield*

*Harshfield* has been removed as prior art. *Bai* is discussed above. *Fu* teaches a method for forming aluminum contacts including the intermediate step of forming a TiN layer by sputtering a titanium target in a nitrogen atmosphere. (*Fu*, col. 2, ll. 48-53.) *Fu* further teaches treating the TiN layer with an argon plasma to smooth the TiN layer and improve the wettability of a subsequently deposited aluminum layer. (*Fu*, col. 2, ll. 53-65.) *Fu* does not teach or suggest forming a layer of metal nitride using a gas comprising a metallo-organic substance, as recited in claim 54.

As such, *Fu* cannot be used to modify *Bai* in a manner that teaches or suggests a method for forming a structure for an integrated circuit including the steps of forming a layer of metal nitride on a refractory metal using a gas comprising a metallo-organic substance, and then exposing the metal nitride layer to a plasma to reduce the resistivity of said layer by removing carbon from the metal nitride layer, as recited in claim 54. Therefore, a *prima facie* case of obviousness has not been established because the combination of the cited references fails to teach or suggest all of the claimed limitations. With respect to the Examiner's alternative stance of taking Official Notice, the Applicants submit that as the claimed invention is patentable over the art cited by the Examiner, Official Notice is not appropriate and should be withdrawn.

Thus, independent claim 54, and all claims depending therefrom, are patentable over *Bai* in view of *Fu* and *Harshfield*. Accordingly, the Applicants respectfully request that the rejection be withdrawn and the claims allowed.

B. Claims 70-74

Claims 70-74 stand rejected as being unpatentable over *Bai* in view of *Ho*, *Hower*, or *Fu*, and *Harshfield*. The Applicants respectfully disagree.

As discussed above, *Bai* does not teach or suggest depositing a second layer of titanium nitride on a first layer wherein the second layer is formed using a gas comprising a metallo-organic substance and said second layer has a thickness of less than 130 angstroms, and then exposing the second layer to a plasma comprising at least one of nitrogen or hydrogen to reduce the resistivity of said second layer by removing carbon from the second layer, as recited in claim 70.

As also discussed above, *Harshfield* is not prior art with respect to the invention and neither *Ho*, *Hower*, nor *Fu* teach or suggest forming the second layer using a gas comprising a metallo-organic substance, as recited in claim 70.

As such, *Ho*, *Hower*, or *Fu* cannot be used to modify *Bai* in a manner that teaches or suggests a method for forming a structure for an integrated circuit including the steps of depositing a second layer of titanium nitride on a first layer wherein the second layer is formed using a gas comprising a metallo-organic substance and said second layer has a thickness of less than 130 angstroms, and then exposing the second layer to a plasma comprising at least one of nitrogen or hydrogen to reduce the resistivity of said second layer by removing carbon from the second layer, as recited in claim 70. Therefore, a *prima facie* case of obviousness has not been established because the combination of the cited references fails to teach or suggest all of the claimed limitations. Thus, independent claim 70, and all claims depending therefrom, are patentable over *Bai* in view of *Ho*, *Hower*, or *Fu*, and *Harshfield*. Accordingly, the Applicants respectfully request that the rejection be withdrawn and the claims allowed.

C. Claims 75-80

Claims 70-74 stand rejected as being unpatentable over *Bai* in view of *Ho*, *Hower*, or *Fu*, and *Harshfield*. In response, the Applicants have amended claim 70 to more clearly recite aspects of the invention. Claim 79 has been cancelled and its limitations incorporated into claim 70.

As discussed above, *Bai* does not teach or suggest depositing a titanium nitride layer upon the titanium layer using chemical vapor deposition of a metal-organic

substance to a thickness of 100Å or less, and then plasma annealing the titanium nitride layer to improve the resistivity of the titanium nitride layer, as recited in claim 75.

As also discussed above, *Harshfield* is not prior art with respect to the invention and neither *Ho*, *Hower*, nor *Fu* teach or suggest forming a titanium nitride layer using chemical vapor deposition of a metal-organic substance, as recited in claim 70.

As such, *Ho*, *Hower*, or *Fu* cannot be used to modify *Bai* in a manner that teaches or suggests a method for forming a structure for an integrated circuit including the steps of depositing a titanium nitride layer upon the titanium layer using chemical vapor deposition of a metal-organic substance to a thickness of 100Å or less, and then plasma annealing the titanium nitride layer to improve the resistivity of the titanium nitride layer, as recited in claim 75. Therefore, a *prima facie* case of obviousness has not been established because the combination of the cited references fails to teach or suggest all of the claimed limitations. Thus, independent claim 75, and all claims depending therefrom, are patentable over *Bai* in view of *Ho*, *Hower*, or *Fu*, and *Harshfield*. Accordingly, the Applicants respectfully request that the rejection be withdrawn and the claims allowed.

### III. 35 U. S. C. §103 Claims 58, 61-63, 66-67, and 73

Claims 58, 61-63, 66-67, and 73 stand rejected as being unpatentable over *Bai* in view of *Ho*, *Hower*, or *Fu*, and *Harshfield*, and further in view of European Patent Application Serial No. EP 0 477 990, published April 1, 1992 to Gilboa *et al.* (hereinafter *Gilboa*). The Applicants respectfully disagree.

As discussed above, claims 58, 61-63, 66-67, and 73 are patentable over *Bai* in view of *Ho*, *Hower*, or *Fu*, and *Harshfield*. *Gilboa* does not teach or suggest depositing a titanium nitride layer upon a titanium layer using chemical vapor deposition of a metal-organic substance, as recited in independent claims 54 and 70.

As such, *Gilboa* may not be used to modify the combined teachings of *Bai*, *Ho*, *Hower*, *Fu*, and *Harshfield*, to obtain a method for forming a structure for an integrated circuit including the steps of forming a layer of metal nitride on a refractory metal using a gas comprising a metallo-organic substance, and then exposing the metal nitride layer

to a plasma to reduce the resistivity of said layer by removing carbon from the metal nitride layer, as recited in claim 54; or depositing a second layer of titanium nitride on a first layer wherein the second layer is formed using a gas comprising a metallo-organic substance and said second layer has a thickness of less than 130 angstroms, and then exposing the second layer to a plasma comprising at least one of nitrogen or hydrogen to reduce the resistivity of said second layer by removing carbon from the second layer, as recited in claim 70.

Therefore, a *prima facie* case of obviousness has not been established because the combination of the cited references fails to teach or suggest all of the claimed limitations. Thus, independent claims 54 and 70, and all claims depending therefrom, are patentable over *Bai* in view of *Ho*, *Hower*, or *Fu*, and *Harshfield*, and further in view of *Gilboa*. Accordingly, the Applicants respectfully request that the rejection be withdrawn and the claims allowed.

#### IV. 35 U. S. C. §103 Claims 54-80

Claims 54-80 stand rejected as being unpatentable over United States Patent Serial No. 4,960,732, issued October 2, 1990 to Dixit *et al.* (hereinafter *Dixit*) or United States Patent Serial No. 5,732,382, issued March 3, 1998 to Sandhu *et al.* (hereinafter *Sandhu*), in view of the publication of Suguro *et al.*, Applied Surface Science, 41/42 (1989) 277-281, (hereinafter *Suguro*), *Harshfield*, and *Ho* or *Fu*. The Applicants respectfully disagree.

Independent claims 54, 70, and 75 recite limitations not recited by any permissible combination of the cited art. *Dixit* teaches forming a contact plug and interconnect employing a barrier lining wherein a layer of titanium nitride is deposited on top or a layer of titanium. However, *Dixit* does not teach or suggest depositing a layer of metal nitride (or titanium nitride) from a metallo-organic substance, or plasma treating the metal nitride to improve the resistivity of the metal nitride layer, as recited in independent claims 54, 70, and 75.

*Sandhu* mentions depositing a titanium nitride film from a metallo-organic substance. However, the Applicants respectfully submit that *Sandhu* is not prior art with



respect to these teachings. As discussed above with respect to *Harshfield*, the 08/498,990 Application, filed July 6, 1995, from which the instant Application is a Continuation-In-Part, discloses the plasma treatment of a metal nitride film formed from a metallo-organic substance. As the filing date of *Sandhu* is July 31, 1995, *Sandhu* is not prior art with respect to this teaching. Accordingly, the Applicants respectfully request that this reference be withdrawn.

*Suguro* does not teach or suggest depositing a metal nitride layer atop a refractory metal layer using a metallo-organic substance and then exposing the metal nitride layer to a plasma to remove carbon from the metal nitride layer, as recited in claims 54, 70, and 75. Nor, as discussed above, do *Ho* or *Fu*.

As such, none of the applicable references teaches or suggests depositing a metal nitride layer atop a refractory metal layer using a metallo-organic substance and then exposing the metal nitride layer to a plasma to remove carbon from the metal nitride layer, as recited in claims 54, 70, and 75.

Therefore, a *prima facie* case of obviousness has not been established because the combination of the cited references fails to teach or suggest all of the claimed limitations. With respect to the Examiner's alternative stance of taking Official Notice, The Applicants submit that as the claimed invention is patentable over the art cited by the Examiner, Official Notice is not appropriate and should be withdrawn.

Thus, independent claims 54, 70, and 75, and all claims depending therefrom, are patentable over *Dixit* or *Sandhu* in view of *Suguro*, *Harshfield*, and *Ho* or *Fu*. Accordingly, the Applicants respectfully request that the rejection be withdrawn and the claims allowed.

**V. 35 U. S. C. §103 Claims 58, 61-63, 66-67, and 73**

Claims 58, 61-63, 66-67, and 73 stand rejected as being unpatentable over *Dixit* or *Sandhu* in view of *Suguro*, *Harshfield*, and *Ho* or *Fu*, and further in view of *Gilboa*. The Applicants respectfully disagree.

As discussed above, *Gilboa* may not be used to modify any permissible combination of the base references to teach or suggest depositing a metal nitride layer

atop a refractory metal layer using a metallo-organic substance and then exposing the metal nitride layer to a plasma to remove carbon from the metal nitride layer, as recited in claims 54, and 70.

Therefore, a *prima facie* case of obviousness has not been established because the combination of the cited references fails to teach or suggest all of the claimed limitations. Thus, independent claims 54, and 70, and all claims depending therefrom, are patentable over *Dixit* or *Sandhu* in view of *Suguro*, *Harshfield*, and *Ho* or *Fu*, and further in view of *Gilboa*. Accordingly, the Applicants respectfully request that the rejection be withdrawn and the claims allowed.

#### VI. 35 U. S. C. §103 Claim 77

Claim 77 stands rejected as being unpatentable over *Dixit* or *Sandhu* in view of *Suguro*, *Harshfield*, and *Ho* or *Fu*; or *Bai* in view of *Ho*, *Hower*, or *Fu*, and *Harshfield*; and further in view of United States Patent Serial No. 4,897,282, issued January 30, 1990 to *Kniseley et al.* (hereinafter *Kniseley*). The Applicants respectfully disagree.

*Kniseley* does not teach or suggest depositing a metal nitride layer atop a refractory metal layer using a metallo-organic substance and then exposing the metal nitride layer to a plasma to remove carbon from the metal nitride layer, as recited in claim 75.

As such, *Kniseley* may not be used to modify any permissible combination of the base references, as discussed above, to teach or suggest depositing a metal nitride layer atop a refractory metal layer using a metallo-organic substance and then exposing the metal nitride layer to a plasma to remove carbon from the metal nitride layer, as recited in claim 75.

Therefore, a *prima facie* case of obviousness has not been established because the combination of the cited references fails to teach or suggest all of the claimed limitations. Thus, independent claim 75, and all claims depending therefrom, are patentable over *Dixit* or *Sandhu* in view of *Suguro*, *Harshfield*, and *Ho* or *Fu*; or *Bai* in view of *Ho*, *Hower*, or *Fu*, and *Harshfield*; and further in view of *Kniseley*. Accordingly,

the Applicants respectfully request that the rejection be withdrawn and the claims allowed.

### **DOUBLE PATENTING**

Claims 54-80 stand rejected under the judicially created doctrine of obviousness-type double patenting as being unpatentable over claims 1-41 of United States Patent Serial No. 5,989,999, issued November 23, 1999 to Levine *et al.*, in view of any of *Dixit*, *Sandhu*, or *Suguro*. In response, the Applicants have filed herewith a terminal disclaimer under 37 C.F.R. 1.130(b). As such, Applicants respectfully request that the obviousness-type double patenting rejection be withdrawn.

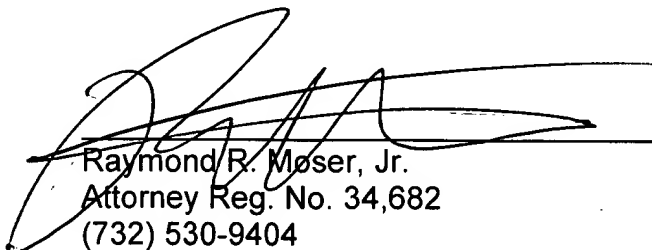
### **CONCLUSION**

Thus, applicants submit that all of the pending claims are presently in condition for allowance. Accordingly, both reconsideration of this application and its swift passage to issue are earnestly solicited.

If, however, the Examiner believes that there are any unresolved issues requiring adverse final action for any of the claims now pending in this application, it is requested that the Examiner telephone Mr. Raymond R. Moser, Jr. at (732) 530-9404, so that appropriate arrangements can be made for resolving such issues as expeditiously as possible.

Respectfully submitted,

2-27-04  
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CERTIFICATE OF TRANSMISSION UNDER 37 C.F.R. 1.8

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